FORM PTO-1390 (Modified) (REV 10-95) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
2024	10/069310

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE 00/02727	August 10, ,2000	AUGUST 11, 1999

TITLE OF INVENTION

FUEL INJECTION VALVE AND METHOD FOR PRODUCING OUTLET OPENINGS IN VALVES

APPLICANT(S) FOR DO/EO/US

Martin MAIER, Guenther HOHL, Guneter DANTES, Detlef NOWAK, Joerg HEYSE, Norbert KEIM

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 18 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
    A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☐ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☒ Certificate of Mailing by Express Mail
19. ☐ Other items or information:

EL 755323852 US

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/069310	PCT/DE 00/02727	2024

20. The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		CALCULATIONS PTO USE ONLY
☐ Search Report has been prepared by the EPO or JPO	$930.00	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482)	$720.00	
☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))	$790.00	
☒ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO	$1,070.00	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)	$98.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =		$890.00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		$0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	21 - 20 =	1	x $18.00	$18.00	
Independent claims	1 - 3 =	0	x $80.00	$0.00	
Multiple Dependent Claims **(check if applicable).**			☐	$0.00	
TOTAL OF ABOVE CALCULATIONS =				$908.00	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).**			☐	$0.00	
SUBTOTAL =				$908.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	$0.00	
TOTAL NATIONAL FEE =				$908.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	$0.00	
TOTAL FEES ENCLOSED =				$908.00	
				Amount to be: refunded	$
				charged	$

☐ A check in the amount of to cover the above fees is enclosed.

☒ Please charge my Deposit Account No. **19-4675** in the amount of **$908.00** to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **19-4675** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

STRIKER, STRIKER & STENBY
103 EAST NECK ROAD
HUNTINGTON, NEW YORK 11743

SIGNATURE

MICHAEL J. STRIKER
NAME

27233
REGISTRATION NUMBER

FEBRUARY 11, 2002
DATE

UNITED STATES PATENT AND TRADEMARK OFFICE

Examiner: Group: Attorney Docket # 2024

Applicant(s) : MAIER, M., ET AL

Serial No. :

Filed :

For : FUEL INJECTION VALVE AND METHOD FOR PRODUCING OUTLET OPENINGS IN VALVES

SIMULTANEOUS AMENDMENT

February 11, 2002

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

S I R S:

Simultaneously with filing of the above identified application please amend the same as follows:

In the Claims:

Cancel all claims without prejudice.

Substitute the claims attached hereto.

REMARKS:

This Amendment is submitted simultaneously with filing of the above identified application.

With the present Amendment applicant has amended the claims so as to eliminate their multiple dependency.

Consideration and allowance of the present application is most respectfully requested.

Respectfully submitted,

Michael J. Striker
Attorney for Applicant(s)
Reg. No. 27233

UNITED STATES PATENT AND TRADEMARK OFFICE

In re:

Applicant: MAIER

Serial No.: 10/069,310

Docket No.: 2024

Filed: February 11, 2002

PRELIMINARY AMENDMENT

March 27, 2002

Hon. Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Preliminarily to the issuance of an Office Action in the above identified application, please amend the application as follows:

Box: PCT.

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231.
On 3/27/02

In the specification:

Please amend the specification as attached.

In the claims:

Cancel all claims without prejudice.

Add the claims as attached.

REMARKS

This Amendment is submitted preliminarily to the issuance of an Office Action in the above identified application.

With the present Amendment applicant has amended the specification to bring it in compliance with the requirements of the U.S. Patent Practice.

The original claims have been canceled and replaced with a new set of claims 22-42 which include claim 22, the broadest apparatus claim, claims 22 and 37, the broadest method claims and the dependent claims which depend on the corresponding independent claims.

Consideration and allowance of present application is most respectfully requested.

Should the Examiner require or consider it advisable that the specification, claims and/or drawings be further amended or corrected in formal respects in order to place this case in condition for final allowance, then it is respectfully requested that such amendments or corrections be

carried out by Examiner's Amendment, and the case be passed to issue. Any costs involved should be charged to the deposit account of the undersigned (No. 19-4675). Alternatively, should the Examiner feel that a personal discussion might be helpful in advancing this case to allowance, he is invited to telephone the undersigned (at 631-549-4700).

Respectfully submitted,

Michael J. Striker
Attorney for Applicants
Reg. No. 27233

In the specification:

Page 1, line 5, please change the heading "Prior Art" to -- Background of the Invention --.

Page 1, first paragraph in lines 6-10, please amend the paragraph as follows:

The invention is based on a fuel injection valve [as generically defined by the preamble to claim 1] and on a method for producing outlet openings in valves [as generically defined by the preambles to claims 11 and 17].

Page 1, line 25, please change the heading "Advantages of the Invention" to -- Summary of the Invention --.

The paragraph bridging pages 1 and 2, please amend as follows:

The fuel injection valve according to the invention [having the characteristics of the body of claim 1] has the advantage that in a simple,

economical way, a very wide range of variation in terms of flow rates, stream angles and spray properties is attainable. Advantageously, fluctuations in the stream angle are reduced. Moreover, structurings of the stream or spray and the creation of solid- and hollow-conical streams can be achieved more simply, even at high combustion chamber counterpressure, than in known fuel injection valves.

Page 2, lines 25-27, delete this paragraph in its entirety.

Page 3, first paragraph, amend as follows:

The method of the invention [having the characteristics of the body of claim 11 or the body of claim 17] has the advantage that with it, in a simple way, a fuel injection valve can be produced with which the aforementioned advantages are attainable.

Page 3, line 26, change the heading "Drawings" to -- Brief Description of the Drawings --.

Page 4, line 16, change the heading "Description of the Exemplary Embodiments" to -- Description of the Preferred Embodiments --.

Amended specification:

Amended page 1, first paragraph in lines 6-10:

The invention is based on a fuel injection valve and on a method for producing outlet openings in valves.

Amended paragraph bridging pages 1 and 2:

The fuel injection valve according to the invention has the advantage that in a simple, economical way, a very wide range of variation in terms of flow rates, stream angles and spray properties is attainable. Advantageously, fluctuations in the stream angle are reduced. Moreover, structurings of the stream or spray and the creation of solid- and hollow-conical streams can be achieved more simply, even at high combustion chamber counterpressure, than in known fuel injection valves.

CLAIMS

New claims:

22. A fuel injection valve, comprising a fuel inlet; an excitable actuating device; a valve closing member movable by said excitable actuating device; a valve seat element with a fixed seat with which said valve closing member cooperates to open and close the valve; at least one outlet opening as a fuel outlet provided downstream of said valve seat, said at least one outlet opening on its ejection end having an outlet region with a parameter which deviates from a remaining part of said outlet opening and selected from the group consisting of a shape, a size, and a contour, and is recessed from a side of said outlet opening remote from said valve seat and also is contoured independently from said remaining part of said outlet opening; and a swirl-generating means located upstream of said at least one outlet opening and associated with said at least one outlet opening.

23. A fuel injection valve as defined in claim 22, wherein said at least one outlet opening is provided precisely upstream of said valve seat, so that an opening of said swirl generating means is associated with said at least one outlet opening upstream.

24. A fuel injection valve as defined in claim 22, wherein said at least one outlet opening is provided in said valve seat element.

25. A fuel injection valve as defined in claim 22; and further comprising an ejection region provided downstream of said valve seat element, said at least one outlet opening being arranged in said ejection region.

26. A fuel injection valve as defined in claim 22, wherein said outlet region of said outlet opening is polygonal.

27. A fuel injection valve as defined in claim 22, wherein said outlet region of said outlet opening has a shape selected from the group consisting of a widening shape and a tapering shape in form of a truncated pyramid in a flow direction.

28. A fuel injection valve as defined in claim 22, wherein said outlet region of said outlet opening has a cross-section selected from the group consisting of a circular cross-section and an elliptical cross-section.

29. A fuel injection valve as defined in claim 22, wherein said outlet region of said outlet opening has a shape selected from the group consisting of a widening shape or a tapering shape frusticonically in a flow direction.

30. A fuel injection valve as defined in claim 22, wherein said outlet region of said outlet opening is curved in a form selected from the group consisting of a convex form and a concave form.

31. A fuel injection valve as defined in claim 22, wherein said outlet region of said outlet opening has a plurality of portions in succession in a flow direction, which differs from one another by a parameter selected from the group consisting of a shape, a size, and a contour.

32. A method of producing outlet openings in a fuel injection valve having a fuel inlet, an excitable actuating device, a valve closing member movable by the excitable actuating device, a valve seat element having a fixed valve seat with which the valve closing member cooperates for opening and closing the valve, at least one outlet opening as a fuel outlet provide a downstream of the valve seat, and a swirl-generating means located upstream of the at least one outlet opening and associated with the

at least one outlet opening, the method comprising the steps of producing a throughhole in a first method step; and creating in a second method step from an ejection end of the throughhole an outlet region so that it is varied with a parameter selected from the group consisting of a shape, a size, and a contour, compared to the throughhole.

33. A method as defined in claim 32; and further comprising recessing the throughole by a process selected from the group consisting of a stamping, an erosion and a laser beam boring.

34. A method as defined in claim 32; and further comprising recessing the outlet region by a non-metal-cutting production process.

34. A fuel injection valve as defined in claim 32; and further comprising recessing the outlet region with a highly focused, high-energy radiation of beams selected from the group consisting of electron beams and laser beams.

35. A fuel injection valve as defined in claim 32; and further comprising recessing the outlet region by a mold wire erosion.

36. A method as defined in claim 32, wherein said creating the throughhole in the first metal step includes creating the throughhole with a cross-section selected from the group consisting of a circular cross-section and an elliptical cross-section.

37. A method for producing outlet openings in a fuel injection valve having a fuel inlet, an excitable actuating device, a valve closing member movable by the excitable actuating device, a valve closing member cooperating with the valve seat for opening and closing the valve, at least one outlet opening as a fuel outlet provided downstream of the valve seat, a swirl-generating means upstream of the at least one outlet opening, a swirl-generating means associated with the outlet opening, the method comprising the steps of creating in a first method step a blind bore from an inlet side and opposite to an injection end; and creating in a second method step from the injection end of the outlet opening an outlet region up to the blind bore, far enough to create a continuous outlet opening.

38. A method as defined in claim 37; and further comprising recessing the blind bore by a process selected from the group consisting of an erosion and a laser beam boring.

39. A fuel injection valve as defined in claim 37; and further comprising recessing the outlet region by a non-metal-cutting production process.

40. A fuel injection valve as defined in claim 37; and further comprising recessing the outlet region by a highly focused, high-energy radiation, with beams selected from the group consisting of electron beams and laser beams.

41. A fuel injection valve as defined in claim 37; and further comprising recessing the outlet region by a mold wire erosion.

UNITED STATES PATENT AND TRADEMARK OFFICE

In re:

Applicant: MAIER

Serial No.: 10/069,310

Filed: February 11, 2002

SECOND PRELIMINARY AMENDMENT

April 10, 2002

Hon. Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Please amend the application as follows:

Box: DCT

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231.
On 4/10/02

In the claims:

Amend the claims as attached.

Respectfully submitted,

Michael J. Striker
Attorney for Applicants
Reg. No. 27233

CLAIMS

Amend the following claims:

[34] 35. A method [fuel injection valve] as defined in claim 32; and further comprising recessing the outlet region with a highly focused, high-energy radiation of beams selected from the group consisting of electron beams and laser beams.

[35]36. A method [fuel injection valve] as defined in claim 32; and further comprising recessing the outlet region by a mold wire erosion.

[36] 37. A method as defined in claim 32, wherein said creating the throughhole in the first metal step includes creating the throughhole with a cross-section selected from the group consisting of a circular cross-section and an elliptical cross-section.

[37]38. A method for producing outlet openings in a fuel injection valve having a fuel inlet, an excitable actuating device, a valve closing member movable by the excitable actuating device, a valve closing member cooperating with the valve seat for opening and closing the valve,

at least one outlet opening as a fuel outlet provided downstream of the valve seat, a swirl-generating means upstream of the at least one outlet opening, a swirl-generating means associated with the outlet opening, the method comprising the steps of creating in a first method step a blind bore from an inlet side and opposite to an injection end; and creating in a second method step from the injection end of the outlet opening an outlet region up to the blind bore, far enough to create a continuous outlet opening.

[38]39. A method as defined in claim [37] 38; and further comprising recessing the blind bore by a process selected from the group consisting of an erosion and a laser beam boring.

[39] 40. A [fuel injection valve] method as defined in claim [37]38; and further comprising recessing the outlet region by a non-metal-cutting production process.

[40]41. A [fuel injection valve] method as defined in claim [37]38; and further comprising recessing the outlet region by a highly focused, high-energy radiation, with beams selected from the group consisting of electron beams and laser beams.

[41]42. A method [fuel injection valve] as defined in claim [37]38; and further comprising recessing the outlet region by a mold wire erosion.

Amended claims:

35. A method as defined in claim 32; and further comprising recessing the outlet region with a highly focused, high-energy radiation of beams selected from the group consisting of electron beams and laser beams.

36. A method as defined in claim 32; and further comprising recessing the outlet region by a mold wire erosion.

37. A method as defined in claim 32, wherein said creating the throughhole in the first metal step includes creating the throughhole with a cross-section selected from the group consisting of a circular cross-section and an elliptical cross-section.

38. A method for producing outlet openings in a fuel injection valve having a fuel inlet, an excitable actuating device, a valve closing member movable by the excitable actuating device, a valve closing member cooperating with the valve seat for opening and closing the valve, at least one outlet opening as a fuel outlet provided downstream of the valve seat, a swirl-generating means upstream of the at least one outlet opening, a swirl-

generating means associated with the outlet opening, the method comprising the steps of creating in a first method step a blind bore from an inlet side and opposite to an injection end; and creating in a second method step from the injection end of the outlet opening an outlet region up to the blind bore, far enough to create a continuous outlet opening.

39. A method as defined in claim 38; and further comprising recessing the blind bore by a process selected from the group consisting of an erosion and a laser beam boring.

40. A method as defined in claim 38; and further comprising recessing the outlet region by a non-metal-cutting production process.

41. A method as defined in claim 38; and further comprising recessing the outlet region by a highly focused, high-energy radiation, with beams selected from the group consisting of electron beams and laser beams.

42. A method as defined in claim 38; and further comprising recessing the outlet region by a mold wire erosion.

Feburary 11, 2002

DECLARATION

The undersigned, Jan McLin Clayberg, having an office at 5316 Little Falls Road, Arlington, VA 22207-1522, hereby states that she is well acquainted with both the English and German languages and that the attached is a true translation to the best of her knowledge and ability of international patent application PCT/DE 00/02727 of MAIER, R., ET AL., entitled "FUEL INJECTION VALVE AND METHOD FOR PRODUCING OUTLET OPENINGS IN VALVES".

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

Jan McLin Clayberg

Claims

1. A fuel injection valve, having a fuel inlet (2), having an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, having a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates to open and close the valve, having at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32), on its ejection end, has an outlet region (75),

- which deviates in shape and/or size and/or contour from the remaining embodiment of outlet opening (32),

- which can be recessed from the side of the outlet opening (32) remote from the valve seat (27), and

- which is contoured in production terms independently of the remaining embodiment of the outlet opening (32).

2. The fuel injection valve of claim 1, characterized in that upstream of the at least one outlet opening (32), a swirl-generating means (47) is provided.

3. The fuel injection valve of claim 1 [or 2], characterized in that the at least one outlet opening (32) is embodied in the valve seat element (26).

4. The fuel injection valve of claim 1 [or 2], characterized in that an ejection region (67) is disposed

downstream of the valve seat element (26), and the at least one outlet opening (32) is embodied in the ejection region (67).

5. The fuel injection valve of [one of the foregoing claims] claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied polygonally.

6. The fuel injection valve of [one of claims 1-5] claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied as widening or tapering in the form of a truncated pyramid in the flow direction.

7. The fuel injection valve of [one of claims 1-4] claim 1, characterized in that the outlet region (75) of the outlet opening (32) has a circular or elliptical cross section.

8. The fuel injection valve of [one of claims 1-4 or 7] claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied as widening or tapering frustoconically in the flow direction.

9. The fuel injection valve of [one of claims 1-4] claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied as curved in convex or concave form.

10. The fuel injection valve of [one of the foregoing claims] claim 1, characterized in that the outlet region (75) of the outlet opening (32) has a plurality of portions (75', 75'') in succession in the flow direction, which differ from one another in shape and/or size and/or contour.

11. A method for producing outlet openings in a valve, in particular a fuel injection valve of [one of claims 1-10] claim 1, which has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates for opening and closing the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32) is produced in such a way that in a first method step, a through hole is created, and in a second method step, from the ejection end of the through hole, an outlet region (75) is created that is varied in shape and/or size and/or contour compared to the through hole.

12. The method of claim 11, characterized in that the through hole is recessed by means of stamping, erosion or laser beam boring.

13. The method of claim 11 [or 12], characterized in that the recessing of the outlet region (75) is effected by a non-metal-cutting production process.

14. The method of claim 13, characterized in that the recessing of the outlet region (75) is effected with a highly focused, high-energy radiation, in particular with electron or laser beams.

15. The method of claim 13, characterized in that the recessing of the outlet region (75) is effected by means of mold wire erosion.

16. The method of [one of claims 11-15] claim 11, characterized in that the through hole created in the first method step has a circular or elliptical cross section.

17. A method for producing outlet openings in a valve, in particular a fuel injection valve of [one of claims 1-10] claim 1, which has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates for opening and closing the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32) is produced in such a way that in a first method step, a blind bore is created from the inlet-side end opposite the ejection end, and in a second method step, from the ejection end of the outlet opening (32) to be created, an outlet region (75) is created up to the blind bore, far enough to create a continuous outlet opening (32).

18. The method of claim 17, characterized in that the blind bore is recessed by means of erosion or laser beam boring.

19. The method of claim 17 [or 18], characterized in that the recessing of the outlet region (75) is effected by a non-metal-cutting production process.

20. The method of claim 19, characterized in that the recessing of the outlet region (75) is effected with a highly focused, high-energy radiation, in particular with electron or laser beams.

21. The method of claim 19, characterized in that the recessing of the outlet region (75) is effected by means of mold wire erosion.

Claims

1. A fuel injection valve, having a fuel inlet (2), having an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, having a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates to open and close the valve, having at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32), on its ejection end, has an outlet region (75),

- which deviates in shape and/or size and/or contour from the remaining embodiment of outlet opening (32),

- which can be recessed from the side of the outlet opening (32) remote from the valve seat (27), and

- which is contoured in production terms independently of the remaining embodiment of the outlet opening (32).

2. The fuel injection valve of claim 1, characterized in that upstream of the at least one outlet opening (32), a swirl-generating means (47) is provided.

3. The fuel injection valve of claim 1, characterized in that the at least one outlet opening (32) is embodied in the valve seat element (26).

4. The fuel injection valve of claim 1, characterized in that an ejection region (67) is disposed downstream of the valve

seat element (26), and the at least one outlet opening (32) is embodied in the ejection region (67).

5. The fuel injection valve of claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied polygonally.

6. The fuel injection valve of claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied as widening or tapering in the form of a truncated pyramid in the flow direction.

7. The fuel injection valve of claim 1, characterized in that the outlet region (75) of the outlet opening (32) has a circular or elliptical cross section.

8. The fuel injection valve of claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied as widening or tapering frustoconically in the flow direction.

9. The fuel injection valve of claim 1, characterized in that the outlet region (75) of the outlet opening (32) is embodied as curved in convex or concave form.

10. The fuel injection valve of claim 1, characterized in that the outlet region (75) of the outlet opening (32) has a plurality of portions (75', 75'') in succession in the flow direction, which differ from one another in shape and/or size and/or contour.

11. A method for producing outlet openings in a valve, in

particular a fuel injection valve of claim 1, which has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates for opening and closing the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32) is produced in such a way that in a first method step, a through hole is created, and in a second method step, from the ejection end of the through hole, an outlet region (75) is created that is varied in shape and/or size and/or contour compared to the through hole.

12. The method of claim 11, characterized in that the through hole is recessed by means of stamping, erosion or laser beam boring.

13. The method of claim 11, characterized in that the recessing of the outlet region (75) is effected by a non-metal-cutting production process.

14. The method of claim 13, characterized in that the recessing of the outlet region (75) is effected with a highly focused, high-energy radiation, in particular with electron or laser beams.

15. The method of claim 13, characterized in that the recessing of the outlet region (75) is effected by means of mold wire erosion.

16. The method of claim 11, characterized in that the through hole created in the first method step has a circular or

elliptical cross section.

17. A method for producing outlet openings in a valve, in particular a fuel injection valve of claim 1, which has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates for opening and closing the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32) is produced in such a way that in a first method step, a blind bore is created from the inlet-side end opposite the ejection end, and in a second method step, from the ejection end of the outlet opening (32) to be created, an outlet region (75) is created up to the blind bore, far enough to create a continuous outlet opening (32).

18. The method of claim 17, characterized in that the blind bore is recessed by means of erosion or laser beam boring.

19. The method of claim 17, characterized in that the recessing of the outlet region (75) is effected by a non-metal-cutting production process.

20. The method of claim 19, characterized in that the recessing of the outlet region (75) is effected with a highly focused, high-energy radiation, in particular with electron or laser beams.

21. The method of claim 19, characterized in that the recessing of the outlet region (75) is effected by means of mold wire erosion.

FUEL INJECTION VALVE AND METHOD FOR PRODUCING OUTLET OPENINGS IN VALVES

Prior Art

The invention is based on a fuel injection valve as generically defined by the preamble to claim 1 and on a method for producing outlet openings in valves as generically defined by the preambles to claims 11 and 17.

From German Patent Disclosure DE 196 36 396 A1, a fuel injection valve is already known that, downstream of its valve seat face with which a valve closing body cooperates to open and close the valve, has a perforated disk. This cup-shaped perforated disk, shaped from a metal sheet, has many ejection openings, through which the fuel is output, for instance into an intake tube of an internal combustion engine in the direction of an inlet valve. These ejection openings are made in the perforated disk by stamping, erosion or laser beam boring. The ejection openings have a continuous constant circular or elliptical cross section over their axial length.

Advantages of the Invention

The fuel injection valve according to the invention having the characteristics of the body of claim 1 has the advantage that in a simple, economical way, a very wide range of variation in terms of flow rates, stream angles and spray properties is attainable. Advantageously, fluctuations in the stream angle are reduced. Moreover, structurings of the stream or spray and the creation of solid- and hollow-conical streams can be achieved more simply, even at high combustion

chamber counterpressure, than in known fuel injection valves.

It is advantageous that with the fuel injection valve of the invention, a very high atomization quality of a fuel to be ejected can be attained, as well as shapings of the stream or spray that are adapted to given requirements (such as installation conditions, engine configurations, cylinder recesses, spark plug positions). As a consequence, with such an injection valve, among other things exhaust emissions of the engine can be attained, and a reduction in fuel consumption can also be achieved.

Especially in eccentric outlet openings, in which the center point of the inlet plane is not located on the longitudinal axis of the valve, it is advantageous if the inlet portion of the outlet opening has a relatively small opening width, and the outlet region is then markedly widened. In this way, even with such valves, advantageously small diameters for the valve seat face can be adhered to. Compared with known valves of the same design with eccentric outlet openings, the static hydraulic closing load can be decreased, and the tightness at the valve seat can be improved.

By the provisions recited in the dependent claims, advantageous refinements of and improvements to the fuel injection valve recited in claim 1 are possible.

It is especially advantageous if the fuel is subjected to a swirl upstream of the outlet opening, because then in the contoured outlet region of the outlet opening, local accumulations of fuel are effectively achieved, which in the form of strands are desirable, especially for direct injection of fuel into a combustion chamber.

The method of the invention having the characteristics of the body of claim 11 or the body of claim 17 has the advantage that with it, in a simple way, a fuel injection valve can be produced with which the aforementioned advantages are attainable.

By the provisions recited in the dependent claims, advantageous refinements of and improvements to the method defined by claim 11 and claim 17 are possible.

Because of the high precision, in particular of the laser contour cutting, very exact outlet regions can be recessed, as a result of which the stream angle fluctuations of the ejected fuel spray can be reduced. The shaping of the outlet regions of the outlet openings by means of laser or electron beam erosion is extremely flexible, especially in comparison with mechanical embossing with embossing dies, for instance. For instance, outlet regions of outlet openings can easily be produced that are polygonal, that widen or taper in the form of a truncated pyramid in the flow direction, that have a circular or elliptical cross section, that widen or taper frustoconically in the flow direction, that are curved in convex or concave fashion, or that are embodied in stepped form with multiple portions.

Drawing

Exemplary embodiments of the invention are shown in simplified form in the drawing and explained in further detail in the ensuing description. Fig. 1 shows a fuel injection valve in a longitudinal section; Fig. 2 shows a first, alternative guide and seat region; Fig. 3 shows a second, alternative guide and seat region; Fig. 4 shows a first outlet opening in a view from below; Fig. 5 is a

section taken along the line V-V of Fig. 4; Fig. 6 shows a second outlet opening in a view from below; Fig. 7 is a section taken along the line VII-VII of Fig. 6; Fig. 8 shows a third outlet opening in a view from below; Fig. 9 is a section taken along the line IX-IX of Fig. 8; Fig. 10 shows a fourth outlet opening in a view from below; Fig. 11 is a section taken along the line XI-XI of Fig. 10; Fig. 12 shows a fifth outlet opening in a view from below; Fig. 13 is a section taken along the line XIII-XIII of Fig. 12; Fig. 14 shows a sixth outlet opening in a view from below; Fig. 15 is a section taken along the line XV-XV of Fig. 14; Fig. 16, a section through a seventh outlet opening; Fig. 17, a section through an eighth outlet opening; and Fig. 18, a section through a ninth outlet opening.

Description of the Exemplary Embodiments

The electromagnetically actuated valve in the form of an injection valve for fuel injection systems of externally ignited internal combustion engines, shown as an exemplary embodiment in Fig. 1, has a tubular, largely hollow-cylindrical core 2, acting as the inner pole of a magnetic circuit and at least partly surrounded by a magnet coil 1. The fuel injection valve is especially well suited as a high-pressure injection valve for direct injection of fuel into a combustion chamber of an internal combustion engine. A coil body 3, which for instance is stepped, of plastic receives a winding of the magnet coil 1 and in conjunction with the core 2 and an annular, nonmagnetic intermediate part 4 of L-shaped cross section that is partly surrounded by the magnet coil 1, it makes an especially compact, short structure of the injection valve in the region of the magnet coil 1 possible.

A continuous longitudinal opening 7 is provided in the

core 2, extending along a longitudinal axis 8 of the valve. The core 2 of the magnetic circuit also serves as a fuel inlet neck, and the longitudinal opening acts as a fuel supply conduit. An outer, metal (for instance ferritic) housing part 14 is solidly connected to the core 2 above the magnet coil 1; as the outer pole or outer conductor element, it closes the magnetic circuit and completely surrounds the magnet coil 1, at least circumferentially. On the inlet side, a fuel filter 15 is provided in the longitudinal opening 7 of the core 2; it assures that fuel components that because of their size could cause the injection valve to become stopped up or damaged are filtered out. The fuel filter 15 is fixed in the core 2, for instance being pressed in.

Together with the housing part 14, the core 2 forms the inlet end of the fuel injection valve; the upper housing part 14, viewed downstream in the axial direction, for instance, extends just past the magnet coil 1. The upper housing part 14 is adjoined tightly and solidly by a lower, tubular housing part 16, which for instance encloses or receives an axially movable valve part, comprising an armature 19 and a rodlike valve needle 20, or an elongated valve seat carrier 21. The two housing parts 14 and 18 are solidly joined together, for instance by a surrounding weld seam.

In the exemplary embodiment shown in Fig. 1, the lower housing part 18 and the largely tubular valve seat carrier 21 are solidly joined together by screwing; however, other possible joining methods are welding, soldering or crimping. The sealing between the housing part 18 and the valve seat carrier 21 is effected by means of a sealing ring 22, for instance. The valve seat carrier 21, over its entire axial length, has an inner through opening 24, which extends

concentrically to the longitudinal axis 8 of the valve.

With its lower end 25, which at the same time is the downstream termination of the entire fuel injection valve, the valve seat carrier 21 surrounds a disk-shaped valve seat element 26, fitted into the through opening 24, with a valve seat face 21 that tapers downstream frustoconically. The valve needle 20, which for instance is rod-shaped and has a largely circular cross section, is disposed in the through opening 24; on its downstream end, it has a valve closing portion 28. This valve closing portion 28, which for instance is embodied as spherical or partly spherical or rounded or tapers conically, cooperates in a known manner with the valve seat face 27 provided in the valve seat element 26. The axially movable valve part can also be embodied completely differently from the version shown that has an armature 19, valve needle 20 and valve closing portion 28, for instance as an axially movable valve closing body such as a flat armature. Downstream of the valve seat face 27 in the valve seat element 26, at least one outlet opening 32, designed according to the invention, for the fuel is made. The outlet opening 32 in the exemplary embodiment of Fig. 1 extends concentrically to the longitudinal axis 8 of the valve and ends at a flat, lower face end of the valve seat element 26 that extends perpendicular to the longitudinal axis 8 of the valve.

The actuation of the injection valve is done electromagnetically, in a known manner. As excitable actuating devices, a piezoelectric actuator or a magnetostrictive actuator is equally conceivable, however. Actuation via a controllably pressure-loaded piston is also conceivable. For axial movement of the valve needle 20 and thus for opening counter to the spring force of a restoring

spring 33, disposed in the longitudinal opening 7 of the core 2, or closure of the injection valve, the electromagnetic circuit having the magnet coil 1, core 2, housing parts 14 and 18 and armature 19 is used. The armature 19 is connected, for instance by a weld seam, to the end of the valve needle 20 remote from the valve closing portion 28 and is aligned with the core 2. For guidance of the valve needle 20 during its axial motion with the armature 19 along the longitudinal axis 8 of the valve, on the one hand a guide opening 34, provided in the valve seat carrier 21 on the end toward the armature 19, and on the other a disklike guide element 35, disposed upstream of the valve seat element 26 and having a dimensionally accurate guide opening 55 are used. The armature 19 is surrounded, during its axial motion, by the intermediate part 4.

Between the guide element 35 and the valve seat element 26, there is a further disklike element, specifically a swirl element 47, so that all three elements 35, 47 and 26 rest directly on one another and are received in the valve seat carrier 21. The three disklike elements 35, 47 and 26 are solidly joined to one another, for instance by material engagement.

An adjusting sleeve 38, thrust, pressed or screwed into the longitudinal opening 7 of the core 2, serves to adjust the spring prestressing of the restoring spring 33, which via a centering piece 39 rests with its upstream side on the adjusting sleeve 38 and is braced by its opposite side on the armature 19. In the armature 19, one or more borelike flow conduits 40 are provided, through which the fuel can flow from the longitudinal opening 7 in the core 2 as far as the inside of the through opening 24, via connecting conduits 21, near the guide opening 34 in the valve seat carrier 21, that

are embodied downstream of the flow conduits 40.

The stroke of the valve needle 20 is predetermined by the installed position of the valve seat element 26. A terminal position of the valve needle 20, when the magnet coil 1 is not excited, is defined by the contact of the valve closing portion 28 with the valve seat face 27 of the valve seat element 26, while the other terminal position of the valve needle 20, with the magnet coil 1 excited, is the result of the contact of the armature 19 with the downstream face end of the core 2. In this last-mentioned stop region, the surfaces of the components are chromium-plated, for instance.

The provision of electrical contact for the magnet coil 1 and thus its excitation are effected via contact elements 43, which are also provided, outside the coil body 3, with a plastic spray-coating 44. The plastic spray-coating 44 can also extend over further components (such as the housing parts 14 and 18) of the fuel injection valve. Extending out of the plastic spray-coating 44 is an electrical connection cable 45, by way of which electric current is supplied to the magnet coil 1. The plastic spray-coating 44 protrudes through the upper housing part 14, which is interrupted in this region.

In Figs. 2 and 3, two further examples of guide and seat regions are shown; those parts that remain the same or function the same as in Fig. 1 are identified by the same reference numerals. It should be made clear that all the statements made regarding the production and embodiment of the outlet openings 32 are to be considered independently of the direction of inclination of the outlet openings 32, or the embodiment of the components 26, 27 that have the outlet

openings 32.

In the example shown in Fig. 2, the valve seat element 26 has a flange 64, extending all the way around it, which engages the downstream end of the valve seat carrier 21 from below. The outlet opening 32 is made with an oblique inclination to the longitudinal axis 8 of the valve, for instance, and it ends downstream in a convexly curved ejection region 66.

The example shown in Fig. 3 is largely equivalent to the example shown in Fig. 2; the essential difference is that now an additional, fourth disklike ejection region 67 in the form an injection port disk is provided, which has the outlet opening 32. In comparison to Fig. 2, accordingly the valve seat element 26 is split again downstream of the valve seat face 27. The ejection region 67 and the valve seat element 26 are solidly joined to one another, for instance by means of a weld seam 68 made by laser welding, the welding being done in an annularly encompassing indentation 69. Besides laser welding, bonding or resistance welding, among other methods, are also conceivable as suitable joining processes to make this connection.

In Figs. 4-18, nine variant embodies of outlet openings 32 are shown as examples. Figs. 4, 6, 8, 10, 12 and 14 each show outlet openings 32 in a view from below, with the direction of the view on the outlet openings 32 being represented by arrows 70 in Figs. 1-3. Correspondingly, the sections in Figs. 5, 7, 9, 11, 13 and 15 are always taken along the respective opening axis 71; the opening axis 71 need not necessarily coincide with the longitudinal axis 8 of the valve, as is indicated by the obliquely inclined outlet openings 32 in Figs. 2 and 3.

All the outlet openings 32 according to the invention are distinguished by the fact that they are contoured in at least two production steps. The outlet openings 32 in Figs. 4-13 and 16-18 are made in the applicable component 26, 67 in such a way that in a first method step, a through hole is created. This is done in a conventional way for injection ports of injection valves, by stamping, erosion or laser boring. In a second method step, after that, contouring of the through hole, which until then is for instance circular (or for instance of elliptical cross section) is made, from the ejection end of the through hole. An outlet region 75 of the outlet opening 32 on the ejection side is created, which is altered in shape and/or size and/or contour compared to the through hole. Advantageously, this contouring of the outlet openings 32 is done by a non-metal-cutting production process; the removal of material is in particular accomplished without contact, by means of a strongly focused, high-energy radiation. As a thermal removal method, removal with electron or laser beams is especially attractive.

Figs. 4 and 5 show an outlet opening 32 has a circular cross section in the region of the through hole that is not further contoured, which is adjoined by an outlet region 75 that widens in the downstream direction. This outlet region 75 has the shape of an octagonal truncated pyramid. Conversely, in Figs. 6 and 7 an exemplary embodiment of an outlet opening 32 is shown in which the outlet region 75 is hexagonal, and the walls of the outlet region 75 extend axially parallel to the opening axis 71. Polygonal outlet regions 75 are not limited to having six or eight sides; on the contrary, quite easily and extremely precisely, outlet regions 75 with at least three sides in any arbitrary number of sides can be recessed by removing material using electron or laser beams. The angularity of the outlet region 7 causes

discontinuities in the spray to be ejected. This prevents constrictions of the spray that could otherwise arise in injection at a high counterpressure. It is especially advantageous if, as described in conjunction with Fig. 1, the fuel is subjected to a swirl, because then in the contoured outlet region 75, local accumulations of fuel are effectively achieved, which are desired as strands, particularly in direct injection of fuel into a combustion chamber.

In Figs. 8-11, two exemplary embodiments of outlet openings 32 are shown, which instead of a polygonal outlet region 75 have a circular or an oval/elliptical outlet region 75. In both examples, the outlet region 75 is made in two stages; the portion located the farthest downstream always has the largest opening width. While in the example of Figs. 8 and 9 the first portion 75' is embodied as circular and the second portion 75'' is embodied as elliptical, the first and second portions 75', 75'' in the example of Figs. 10 and 11 each have a circular cross section, and the diameter of the portion 75'' is greater than the diameter of the portion 75'. With the aid of such contoured outlet openings 32, widenings of the fuel stream can easily be achieved, so that the ejected sprays take the form of a round or oval hollow cone.

Figs. 12 and 13 show an exemplary embodiment of an outlet opening 32 that has a frustoconical outlet region 75. Besides a conical variant embodiment that widens in the downstream direction and is shown in Fig. 16, an outlet region 75 that tapers conically in the downstream direction can also be created according to the invention.

In Figs. 14 and 15, an outlet opening 32 is shown which is created by a different mode of production. Instead of a through hole, first, in a first method step, a blind bore is

made in the component 26, 67, for instance by erosion or laser boring. In a second method step, after that, the desired outlet opening 32 is contoured, from the ejection end of the component 26, 67. This contouring of the outlet opening 32 is advantageously again done by a non-metal-cutting production process, and as a removal method, removal with electron or laser beams can be considered in particular. In the example shown, the opening width of the outlet region 75 is less than the opening width of the blind bore made before that.

In Figs. 16-18, three further exemplary embodiments of outlet openings 32 are shown. These outlet openings 32 have either a conical outlet region 75, which widens frustoconically in the flow direction (Fig. 16), or a widening, concavely curved outlet region 75 in the form of a spherical portion (Fig. 17), or a widening, parabolic, convexly curved outlet region 75 (Fig. 18).

Figs. 1-3 show outlet openings 32 whose inlet planes are each disposed centrally, which is meant to indicate that the opening axis 71 intersects the longitudinal axis 8 of the valve precisely in an inlet plane 78 of the outlet opening 32. These points of intersection are marked S in Figs. 2 and 3. If the outlet opening 32 is embodied concentrically to the longitudinal axis 8 of the valve, as shown in Fig. 1, the opening axis 71 and the longitudinal axis 8 of the valve coincide. It should be expressly pointed out that this kind of central embodiment of the outlet opening 32 with respect to the inlet plane 78 in no way is a condition for the fuel injection valve of the invention. On the contrary, the described contoured outlet openings 32 can also be made eccentrically, so that in that case the applicable inlet plane 78 has a center point which is not located on the

longitudinal axis 8 of the valve. Especially in such eccentric outlet openings 32, it is advantageous if the inlet portion of the outlet opening 32 with the inlet plane 78 has a relatively small opening width, and then the outlet region 75 is markedly widened. In this way, even with eccentric outlet openings 32 in the valve seat element 26, small sealing diameters at the valve seat face 27 can be adhered to.

Besides the aforementioned removal methods using electron or laser beams, still other methods are conceivable with which contouring of the outlet opening 32 from its ejection end can be done. Examples are water-jet cutting or mold wire erosion.

Claims

1. A fuel injection valve, having a fuel inlet (2), having an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, having a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates to open and close the valve, having at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32), on its ejection end, has an outlet region (75),

- which deviates in shape and/or size and/or contour from the remaining embodiment of outlet opening (32),

- which can be recessed from the side of the outlet opening (32) remote from the valve seat (27), and

- which is contoured in production terms independently of the remaining embodiment of the outlet opening (32).

2. The fuel injection valve of claim 1, characterized in that upstream of the at least one outlet opening (32), a swirl-generating means (47) is provided.

3. The fuel injection valve of claim 1 or 2, characterized in that the at least one outlet opening (32) is embodied in the valve seat element (26).

4. The fuel injection valve of claim 1 or 2, characterized in that an ejection region (67) is disposed downstream of the valve seat element (26), and the at least one outlet opening (32) is embodied in the ejection region

(67).

5. The fuel injection valve of one of the foregoing claims, characterized in that the outlet region (75) of the outlet opening (32) is embodied polygonally.

6. The fuel injection valve of one of claims 1-5, characterized in that the outlet region (75) of the outlet opening (32) is embodied as widening or tapering in the form of a truncated pyramid in the flow direction.

7. The fuel injection valve of one of claims 1-4, characterized in that the outlet region (75) of the outlet opening (32) has a circular or elliptical cross section.

8. The fuel injection valve of one of claims 1-4 or 7, characterized in that the outlet region (75) of the outlet opening (32) is embodied as widening or tapering frustoconically in the flow direction.

9. The fuel injection valve of one of claims 1-4, characterized in that the outlet region (75) of the outlet opening (32) is embodied as curved in convex or concave form.

10. The fuel injection valve of one of the foregoing claims, characterized in that the outlet region (75) of the outlet opening (32) has a plurality of portions (75', 75'') in succession in the flow direction, which differ from one another in shape and/or size and/or contour.

11. A method for producing outlet openings in a valve, in particular a fuel injection valve of one of claims 1-10, which has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a

fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates for opening and closing the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32) is produced in such a way that in a first method step, a through hole is created, and in a second method step, from the ejection end of the through hole, an outlet region (75) is created that is varied in shape and/or size and/or contour compared to the through hole.

12. The method of claim 11, characterized in that the through hole is recessed by means of stamping, erosion or laser beam boring.

13. The method of claim 11 or 12, characterized in that the recessing of the outlet region (75) is effected by a non-metal-cutting production process.

14. The method of claim 13, characterized in that the recessing of the outlet region (75) is effected with a highly focused, high-energy radiation, in particular with electron or laser beams.

15. The method of claim 13, characterized in that the recessing of the outlet region (75) is effected by means of mold wire erosion.

16. The method of one of claims 11-15, characterized in that the through hole created in the first method step has a circular or elliptical cross section.

17. A method for producing outlet openings in a valve, in particular a fuel injection valve of one of claims 1-10,

which has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates for opening and closing the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27), characterized in that the at least one outlet opening (32) is produced in such a way that in a first method step, a blind bore is created from the inlet-side end opposite the ejection end, and in a second method step, from the ejection end of the outlet opening (32) to be created, an outlet region (75) is created up to the blind bore, far enough to create a continuous outlet opening (32).

18. The method of claim 17, characterized in that the blind bore is recessed by means of erosion or laser beam boring.

19. The method of claim 17 or 18, characterized in that the recessing of the outlet region (75) is effected by a non-metal-cutting production process.

20. The method of claim 19, characterized in that the recessing of the outlet region (75) is effected with a highly focused, high-energy radiation, in particular with electron or laser beams.

21. The method of claim 19, characterized in that the recessing of the outlet region (75) is effected by means of mold wire erosion.

Abstract

The invention relates among others to a method for producing outlet openings (32) in a valve, in particular a fuel injection valve. The injection valve has a fuel inlet (2), an excitable actuating device (1, 2, 19) by which a valve closing member (28) is movable, a fixed valve seat (27) embodied on a valve seat element (26), with which seat the valve closing member (28) cooperates to open and close the valve, and at least one outlet opening (32), as a fuel outlet, provided downstream of the valve seat (27). The at least one outlet opening 32 is produced in such a way that in a first method step, a through hole is created in the valve seat element (26), and in a second method step, from the ejection end of the through hole, an outlet region is created that is altered in shape and/or size and/or contour compared to the through hole.

(Fig. 1)

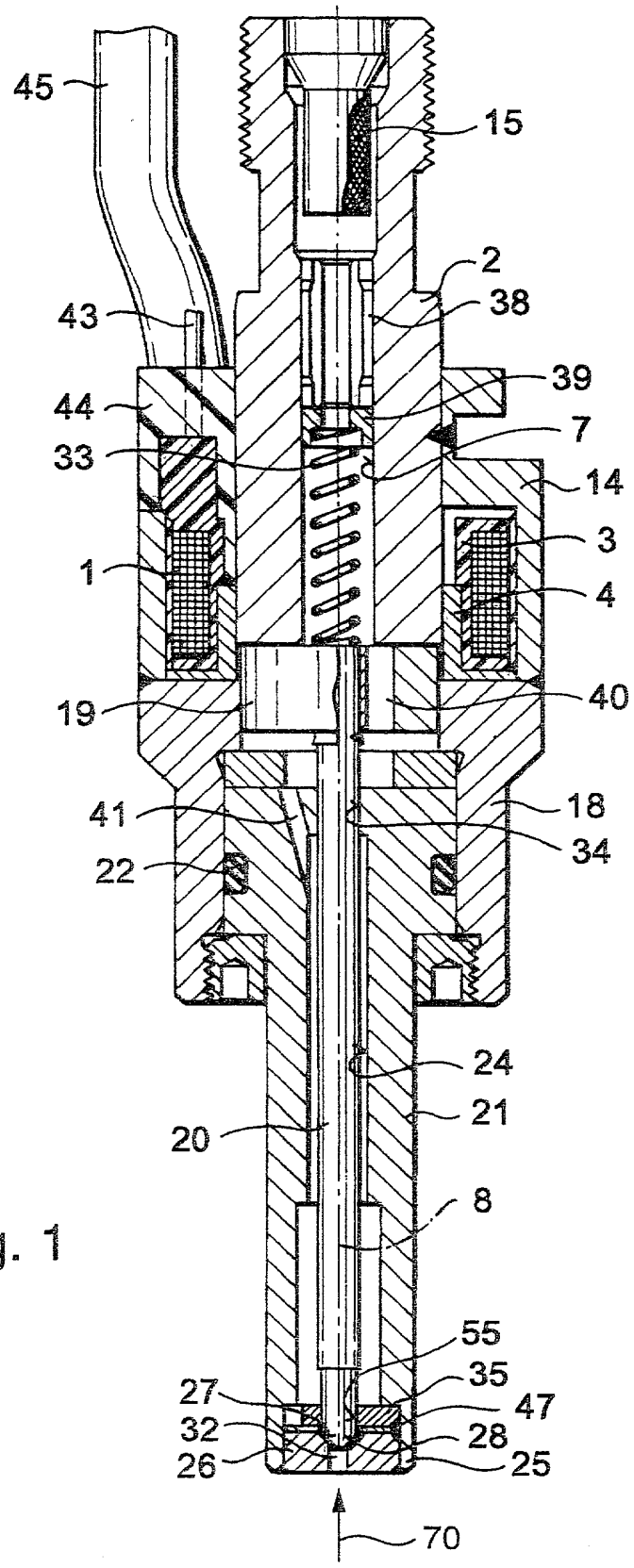
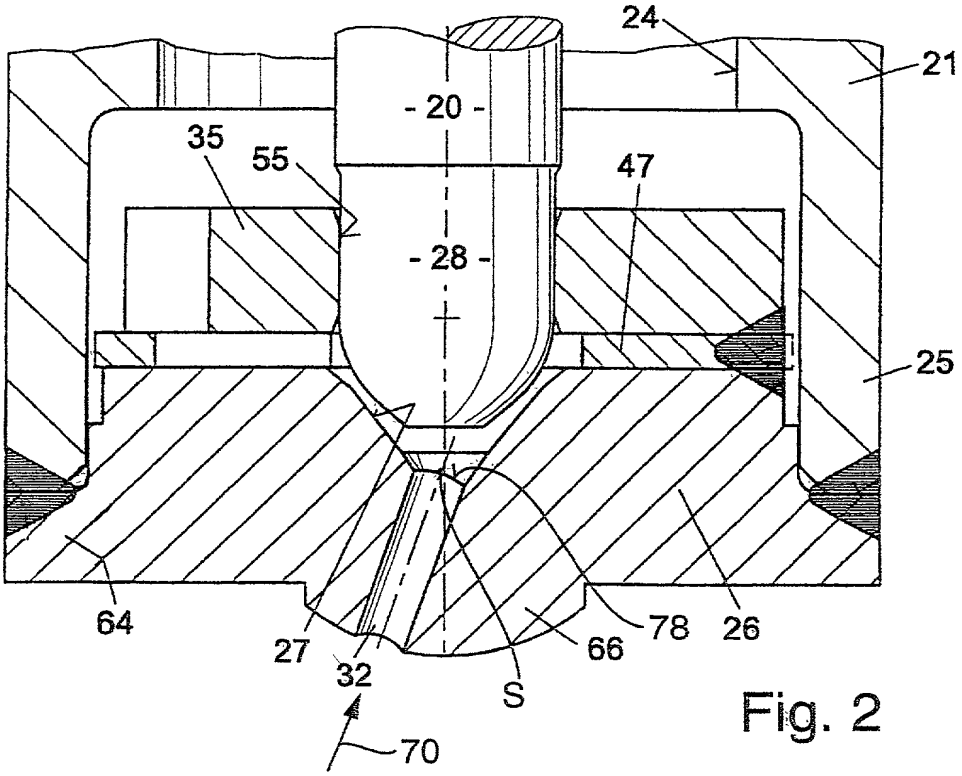


Fig. 1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70

Fig. 2

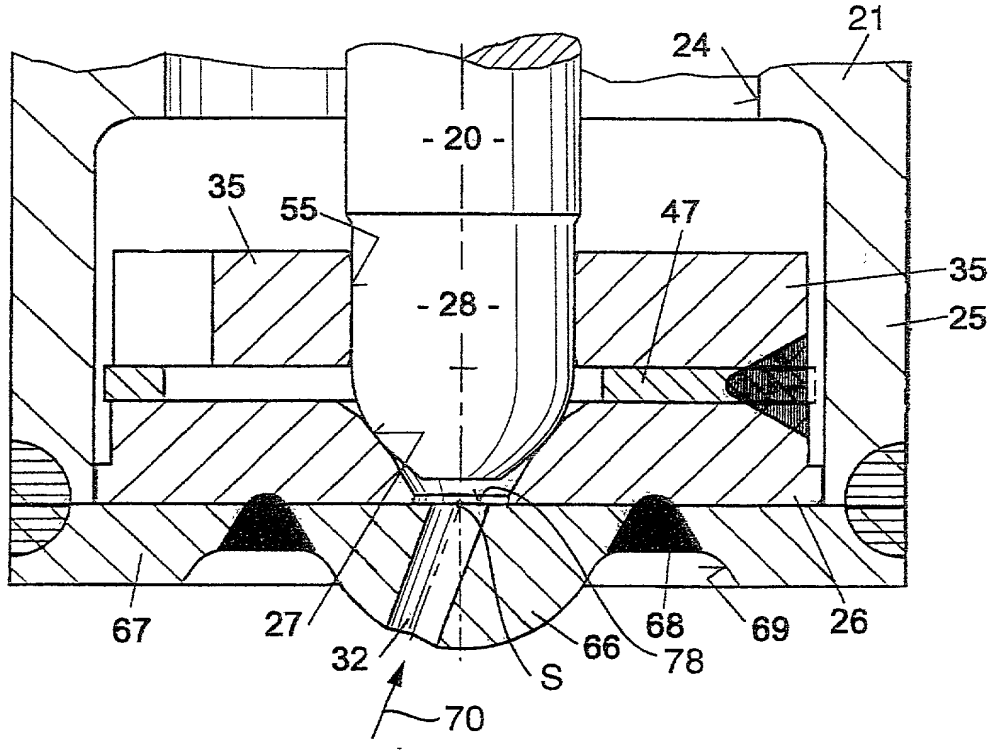
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Fig. 3

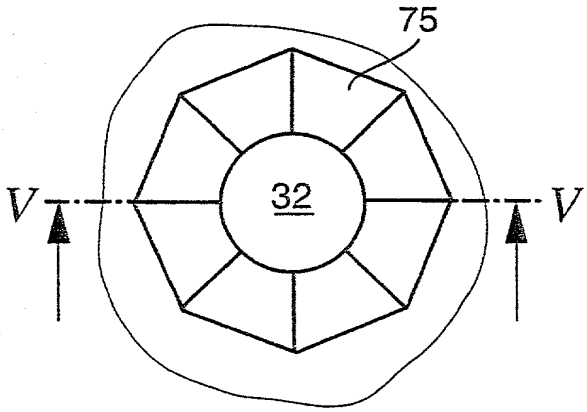

Fig. 4

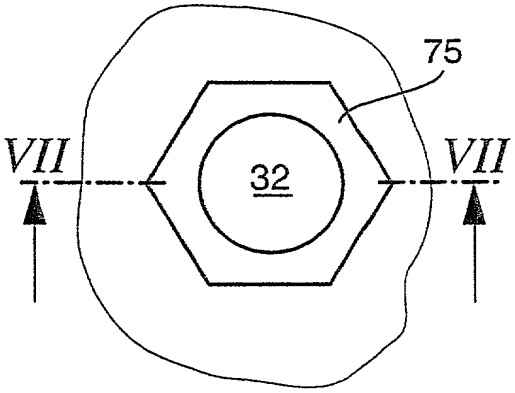

Fig. 6

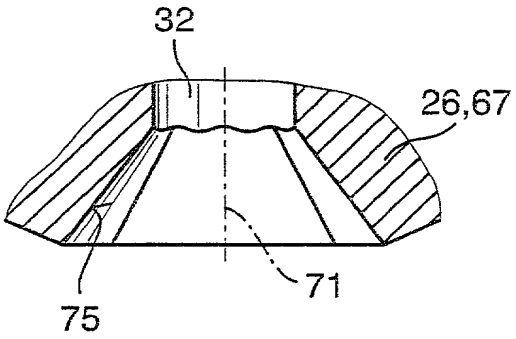

Fig. 5

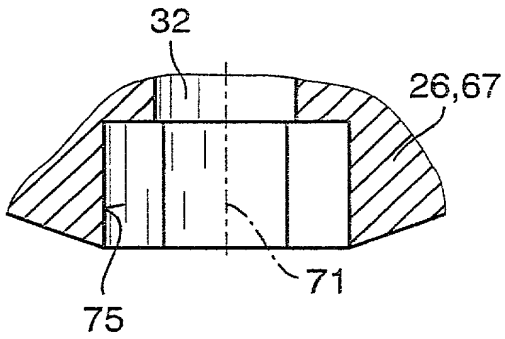

Fig. 7

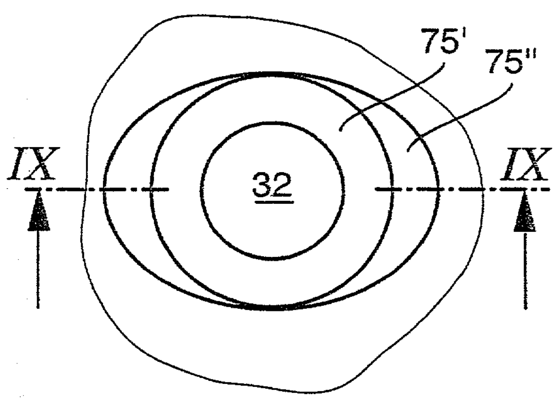

Fig. 8

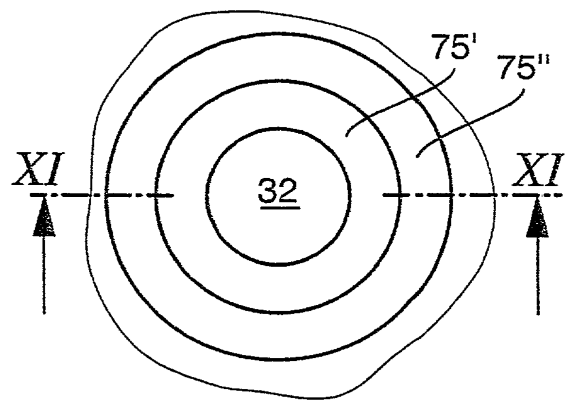

Fig. 10

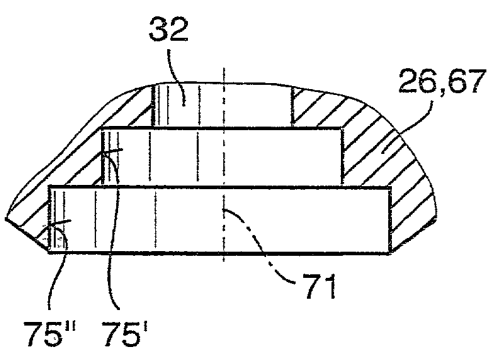

Fig. 9

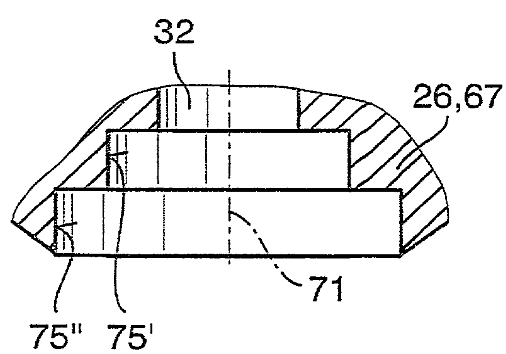

Fig. 11

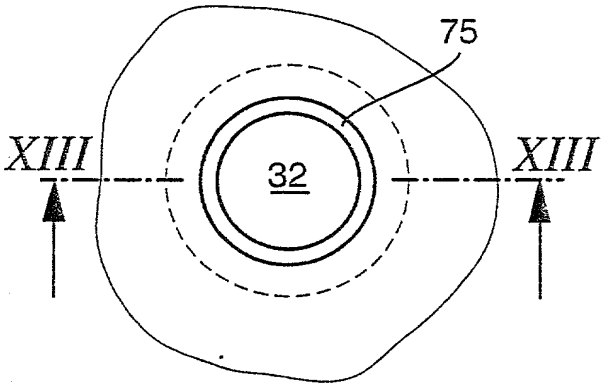

Fig. 12

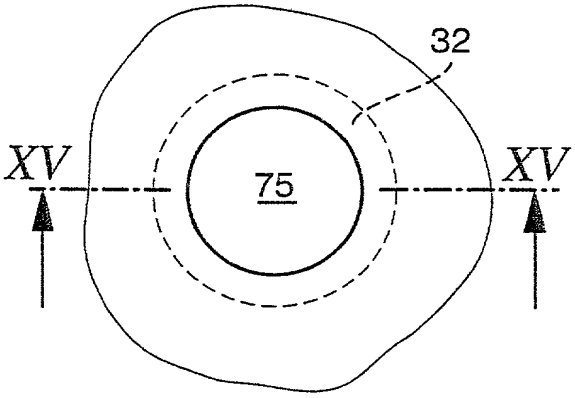

Fig. 14

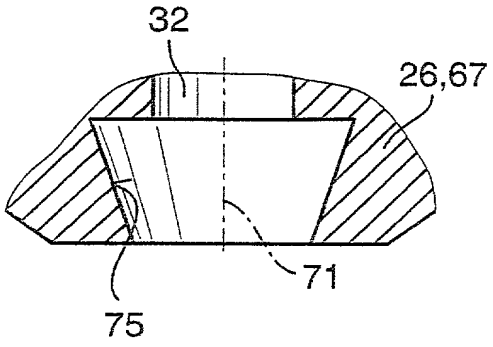

Fig. 13

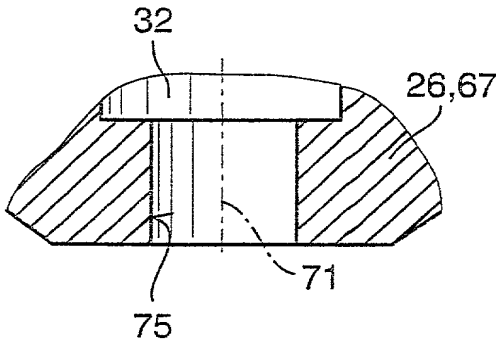

Fig. 15

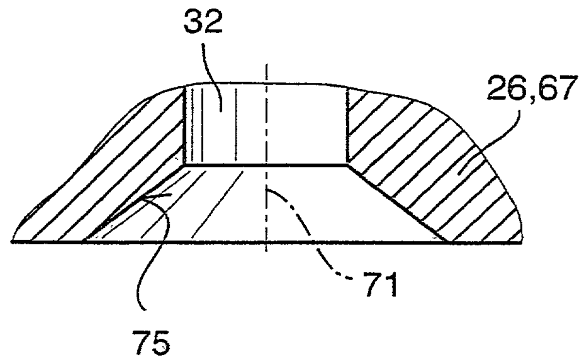

Fig. 16

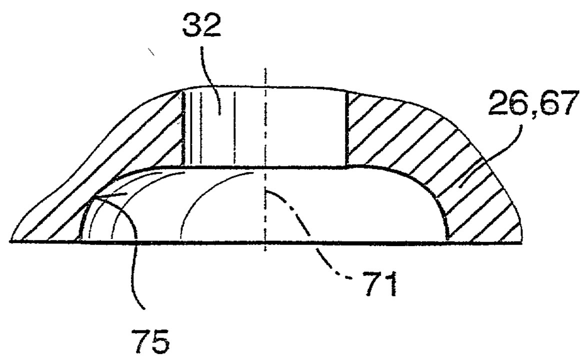

Fig. 17

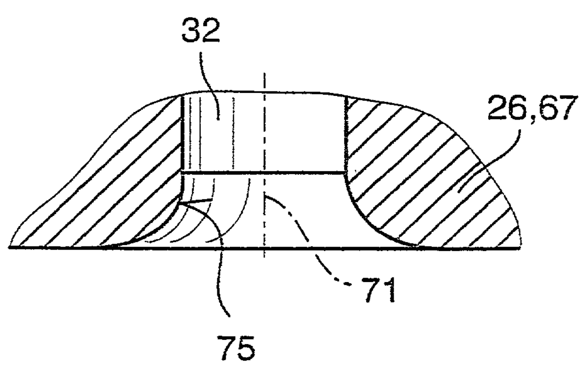

Fig. 18

#4

DECLARATION AND POWER OF ATTORNEY FOR NATIONAL STAGE OF PCT PATENT APPLICATION

As a below-named inventor, I hereby declare that:

Martin MAIER	Detlef NOWAK
Guenther HOHL	Joerg HEYSE
Guenter DANTES	Norbert KEIM

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **FUEL INJECTION VALVE AND METHOD FOR PRODUCING OUTLET OPENINGS IN VALVES** the specification of which was filed as PCT International Application number PCT/DE 00/02727 filed on August 10, 2000.

I hereby state that I believe the named inventor or inventors in this Declaration to be the original and first inventor or inventors of the subject matter which is claimed and for which a patent is sought.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365 (b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior foreign application(s):			Priority claimed:	
199 37 961.0	GERMANY	AUGUST 11, 1999	X	
(Number)	(Country)	(Date filed)	Yes	No
(Number)	(Country)	(Date filed)	Yes	No

As a named inventor, I hereby appoint the following attorney to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment,

or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statement may jeopardize the validity of the application or any patent issued thereon.

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